

## VODONIČKA EKONOMIJA / EKOSISTEM U BOSNI I HERCEGOVINI

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*Stručni članak*

**Sažetak:** "EUROPEAN HYDROGEN WEEK BRUSSELS EXPO" je po treći put organizovan u Briselu od 24. do 28. oktobra 2022. godine. Događaj je potaknut izazovima energetske krize u svijetu a za Bosnu i Hercegovinu je prilika za uključivanje u naučno-istraživačke tokove u ovoj oblasti. Uporedo sa tim, obavezuje autoritete u naučno-istraživačkom krugu da pruže neophodne informacije javnosti i da daju doprinos u savladavanju izazova. Neophodno je da fokus bude usmjeren na Bosansko-Hercegovačke dosege u oblasti ekonomije vodonika, u kojem imamo određena iskustva i znanja, te moguće razvojne, istraživačke i proizvodne potencijale koji zasigurno postoje. Evropske asocijacije iz oblasti vodonikove ekonomije ili ekosistema imaju viziju da uspostave i razvijaju društvo sa nultom emisijom CO<sub>2</sub>. Ekonomija vodonika će zasigurno načiniti novu energetska mapu evrope i svijeta. U tim mapama i vizijama Bosna i Hercegovina može da igra jednu od ključnih uloga.

**Ključne riječi:** vodonik, energija, razvoj, ekosistem

## HYDROGEN ECONOMY / ECOSYSTEM IN BOSNIA AND HERZEGOVINA

**Summary:** "EUROPEAN HYDROGEN WEEK BRUSSELS EXPO" was organized for the third time in Brussels from October 24 to 28, 2022. The event is motivated by the challenges of the energy crisis in the world, and it is an opportunity for Bosnia and Herzegovina to get involved in scientific research in this area. At the same time, it obliges the authorities in the scientific and research circle to provide the necessary information to the public and to contribute to overcoming the challenges. It is necessary that the focus be directed to Bosnia-Herzegovina reach in the field of hydrogen economy, in which we have certain experience and knowledge, and possible development, research and production potentials that certainly exist. European associations in the field of hydrogen economy or ecosystem have a vision to establish and develop a society with zero CO<sub>2</sub> emissions. The hydrogen economy will certainly create a new energy map of Europe and the world. In those maps and visions, Bosnia and Herzegovina can play one of the key roles.

**Keywords:** hydrogen, energy, development, ecosystem

## 1 UVOD

Ovaj rad je motiviran činjenicom da je treće izdanje “EUROPEAN HYDROGEN WEEK BRUSSELS EXPO“ održano je u Briselu od 24. do 28. oktobra 2022. godine a da u Bosni i Hercegovini nema jednostavne i lako razumljive priče o alternativnim izvorima energije. O ovim temama se komunicira posebnim kanalima između „posebnih“ učesnika. Alternativni izvori i informacije o njima su u Bosni i Hercegovini na nivou tabu teme. Takođe je činjenica da u ovoj zemlji ovim pitanjima i informacijama raspolaže mnogo veći broj ljudi nego li što je aktuelnih učesnika u komunikaciji. Dodatni problem je to što se o ovim temama ne govori na način da ih razumije i budu interesantne širokoj javnosti. Dakle ključni izazov u Bosni i Hercegovini jeste radoznalost, zanimljivost, pristupačnost i razumljivost ovih tema. Za razliku od Bosne i Hercegovine u Evropi je sajam u Briselu čistih sedam dana informacija, rasprava i susreta na temu ekonomije vodonika. Ovo je najvažniji događaj u Evropi gdje je tema vodonik i sve o vodoniku. Ovaj događaj je eksplicitan pokazatelj kako se realizuje bezkompleksna saradnja između Evropske komisije, „Hydrogen Europe“ (krovna asocijacija) i „Hydrogen Europe Research“. Stvari su vrlo jednostavne, ljudi imaju problem i okupili su se da ga rješavaju. U ovom partnerstvu nema kompleksa više ili manje vrijednosti, nema odmeđivanja moći, nema tumačenja mišljenja i sličnih pojava. Sve je usmjereno na pitanje „Kako živjeti budućnost?“ i to je to.



Slika 1: Logo-znak asocijacija

U skladu sa Uredbom vjeća (EU) 2021/2085 od 19. decembra 2021. o osnivanju zajedničkih poduzeća u okviru programa Obzor Europa te o stavljanju izvan snage uredbi (EZ) br. 219/2007, ... i (EU) br. 642/2014 osnovana je međunarodna neprofitna asocijacija pod nazivom “Hydrogen Europe”. Asocijacija je osnovana s fokusom na evropsku industrijsku grupaciju za zajedničku tehnološku inicijativu za vodonik i gorive ćelije, te ima viziju da osigura društvo s nultom emisijom CO<sub>2</sub> uz pomoć tehnologije čistog vodonika.

## 2 MOBILNOST U BOSNI I HERCEGOVINI KAO DRUŠTVENI IZAZOV

Evropska unija je usvojila zajednička pravila za zaštitu, socijalne standarde, tehničke i sigurnosne standarde, pomoć države i liberalizaciju tržišta drumskog saobraćaja, željezničkog i saobraćaja unutrašnjim plovnim putevima, kombinovanog saobraćaja, te vazdušnog i pomorskog saobraćaja.

Bosna i Hercegovina mora biti dio Evropskih trendova i mora pristupiti pametnim rješenjima koje zagovara evropska politika i struka. Saobraćajno-transportni sistem treba biti resursno

učinkovit, prihvatljiv za klimu i okoliš, siguran i pouzdan za dobrobit građana, privrede i društva. Bosna i Hercegovina kao dio Evrope mora podmiriti rastuće potrebe za mobilnošću svojih građana i dobra uzrokovane novim demografskim i društvenim promjenama sa uslovima privredne uspješnosti i zahtjevima energetske učinkovitog društva.

## **2.1 Inteligentni, zeleni i integrirani saobraćaj**

Bosna i Hercegovina treba ojačati administrativne kapacitete u pogledu sigurnosti na cestama, te u pogledu izvršnih, inspeksijskih i istražnih tijela za saobraćajno-transportni sistem zemlje.

Bosna i Hercegovina treba da:

- [1] razvije kapacitete za smanjenje saobraćajnih nereda sa smrtnim ishodom i uspostavi sistem za stalno i kontinuirano sakupljanje podataka o saobraćajnim nesrećama;
- [2] ostvari nezavisnost i uspostavi kapacitete za regulatorna tijela u oblasti transporta;
- [3] kreira strateški plan i propise, te osigura kapacitete i resurse za implementaciju inteligentnog transportnog sistema (ITS).

Osnovna obilježja stanja saobraćajno-transportnog sistema u Bosni i Hercegovini su sljedeća:

- Razvoj transportnog sektora i brzina strukturnog prilagođavanja i reformi su nedovoljni.
- Investicije su odgođene zbog političkih blokada i nedostatka saradnje između nivoa vlasti.
- Ograničeni su kapaciteti za zaduživanje.
- Ograničena su finansijska sredstva za pripremu tehničke dokumentacije.
- Izgubljen je fokus na provođenje kratkoročnih i srednjoročnih mjera.

- Nije potpuno usklađivanje s Direktivom o inteligentnim transportnim sistemima (ITS).
- Nepodsticanje multimodalnosti i osiguranje provedbe relevantnih zakona u saobraćaju.
- Bosna i Hercegovina nastavlja aktivno učestvovati u makroregionalnim strategijama EU za razvoj dunavske regije (EUSDR) i jadransko-jonske regije (EUSAIR).
- Zemlja je umjereno pripremljena za drumski saobraćaj.
- Treba provesti mjere za razvoj TEN-T cestovna mreža otporna na klimatske promjene.
- Nije usvojen zakon o međunarodnom drumskom prevozu opasnih materija.
- Nisu usvojene izmjene i dopune Zakona o željeznicama koje su preduslov za formiranje nezavisnih tijela za sigurnost na željeznici.

Održiva mobilnost se osigurava radikalnim promjenama saobraćajno-transportnog sistema, primjenom otkrića u istraživanju saobraćaja i dosljednom provedbom zelenijeg, sigurnijeg, pouzdanijeg i pametnijih transportnih rješenja u Bosni i Hercegovini. Saobraćaj i transport je glavni pokretač privredne konkurentnosti i rasta. Saobraćajna i transportna industrija čine oko 8 % BDP-a u Bosni i Hercegovini.

U Bosni i Hercegovini saobraćaj preko 98% ovisi o fosilnim gorivima. Građani i kompanije očekuju saobraćajno-transportni sistem koji je svima dostupan, siguran i zaštićen. Presudnu ulogu u ostvarivanju ciljeva će imati istraživanje i inovacije usklađene prema političkim ciljevima i namjeri da se ostvari ograničenje globalnog zagrijavanja na 2 °C, smanjene emisije CO<sub>2</sub> za 60 %, zagušenja, troškova nesreća i smrtnosti na cestama.

## 2.2 Ciljevi ključnih politika evropske unije

Što se tiče evropskih politika izdvajaju se četiri ključne osmišljene s namjerom da se omogućiti potreban nivo organizovanja specifičnog način pristupa bilo kojoj vrsti prevoza.

Najznačajnije je zadržati fokus na ostvarenju ciljeva:

- Ekološki prihvatljiv i efikasan prevoza (klima, okoliš, kvalitet, efikasnost i resursi).
- Optimizacija i racionalizacija mobilnosti (manje gužvi, sigurnost, usklađivanje, nova rj.).
- Osigurati vodeću ulogu evropske transportne industrije (jačanje konkurentnost, usluge...).
- Utemeljenje politika (socio-ekonomskim i bihevioralnim istraživanjima).

## 3 ENERGETSKI POTENCIJAL - ALTERNATIVE

Energetski sektor na svjetskom i lokalnom nivou obilježavaju drastične promjene i tranzicija. Globalne politike zasnovane su ili primorane preokretu ka čistoj energiji i ubrzanom razvoju novih i komercijalno dostupnih tehnologija. Zato se razlikuju trendovi razvijenih i zemalja u razvoju.

### 3.1 Globalni energetske trendovi

Zasnovan na analitičkom praćenju promjena procjenjuje se da će potražnja za energijom rasti 24% u narednih 20 godina (od 2015. god.). Očekivano je da će rat dolaziti iz Kine, Indije i zemalja u razvoju. Potražnja je uzrokovana izraženom industrijalizacijom i brzo rastućim ekonomijama. Udjel nafte i uglja će sa 60% učešća 2015. godine pasti na 52% do 2040. g. Bez obzira na trend smanjenja u udjelu nafte, ipak će do 2040. godine potražnja za

primarnom energijom iz nafte u apsolutnim iznosima porasti za 18%. Pored ekonomija u razvoju porast će se odnositi na sektor transporta i petrohemijske industriji. Procjene su da će električna i hibridna vozila činiti 15% do 20% ukupnog voznog parka, što će smanjiti potrošnju nafte.



Slika 2. Struktura globalne potražnje za primarnom energijom, 2015-2040 (Izvor: Okvirna Energetska strategija BiH do 2035 godine) i Neto proizvedena električna energija iz obnovljivih i ne-obnovljivih izvora, (Izvor: Eurostat)

### 3.2 Potrošnja i proizvodnja energije u Bosni i Hercegovini

U narednim tabelama dati su glavni podatci o energetske pokazateljima proizvodnje i potrošnje u Bosni i Hercegovini za 2019. godinu.

Proizvedeno	Količina (GWh)	Udio (%)
<b>Bruto proizvodnja električne energije</b>	17.493	100
u hidroelektranama	6.172	35,3
u termoelektranama	10.625	60,7
u industrijskim energanama i ostalim (vjetar i sunce)	696	4

Tabela 1. Proizvodnja električne energije u Bosni i Hercegovini (Izvor: Autor na osnovu statističkih izvještaja)

Potrošnja	Količina (GWh)	Udio (%)
domaćinstva	7.497	43
industrija	5.737	32,9
ostali potrošači (građevina, saobraćaj i poljoprivredu)	4.202	24,1

Tabela 2: Potrošnja električne energije u Bosni i Hercegovini (Izvor: Autor na osnovu statističkih izvještaja)

Proizvedeno	Količina (TJ)	Udio (%)
Ukupna proizvodnja toplotne energije	5.571	100%
u toplanama	3.301	59,2
u termoelektranama	1.688	30,3
u ind. energanama	582	10,5

Tabela 3: Proizvodnja toplotne energije u Bosni i Hercegovini (Izvor: Autor na osnovu statističkih izvještaja)

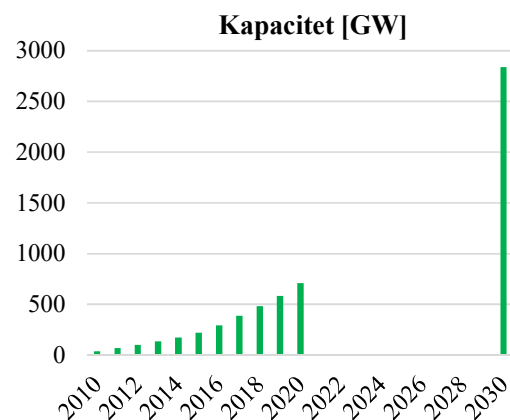
Potrošnja	Količina (TJ)	Udio (%)
domaćinstva	4.240	76,1
industrija i ostali potrošači	1.331	23,9

Tabela 4: Potrošnja toplotne energije u Bosni i Hercegovini (Izvor: Autor na osnovu statističkih izvještaja)

### 3.3 Energetski potencijal solarne energije u Bosni i Hercegovini

Razvoj naprednih tehnologija je na svjetskom nivou dovela do drastičnih promjena koje su promijenile način življenja, komuniciranja, relaksiranja, rada, poslovanja, i stanovanja. U posljednjih nekoliko godina u toku jedne godine dana je instalira preko 100 GW solarnih infrastruktura i fotonaponskih panela. Na taj način je zbirna snaga ovih elektrana dosegla snagu preko 500 GW. Novoizgrađeni kapaciteti solarne energije prevazilaze

kapacitet snage svih drugih novoizgrađenih elektroenergetskih kapaciteta.



Slika 3. Kapaciteti fotonaponskih elektrana u svijetu i očekivane vrijednosti u 2030. godini (Izvor: Autor) i karta fotonaponskog potencijala teritorije BiH (Izvor: <https://solargis.com/>)

Poznato je da sunce isijava ogromni energiju od koje na zemljinoj površini završi oko 10000 TW. Mogućnost iskorištenja ove energije je daleko veća u odnosu na druge obnovljive izvore. Integriranjem fizičke infrastrukture ICT omogućava razmjenu informacija i znanja što je prikazano na sljedećoj slici.



Slika 4. Prosječna vrijednost iradijacije za optimalno i horizontalno postavljene panele na području Bosne i Hercegovine, (Izvor: <https://solargis.com/>)

Prostor	Količina sunčeve energije (prosjeak)
Zemlja planeta	1500 kWh/m <sup>2</sup>
južni dijelovi SAD-a, Australiji i veći dio Afrike	2200 kWh/m <sup>2</sup>
Sjeverna Evropa i Kanadi	1100 kWh/m <sup>2</sup>
Bosna i Hercegovina	1240 do 1600 kWh/m <sup>2</sup>
zemljama srednje i sjeverne Europe	1000 do 1150 kWh/m <sup>2</sup>

Tabela 5: Prosječna količina sunčeve energije koja godišnje dopijeva na Zemljinu površinu (Izvor: Autor)

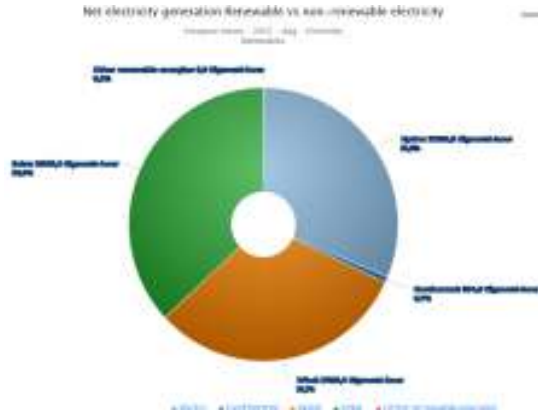
Toplotna snaga sunčevog zračenja na zemljinoj površini u vedrom danu je cca. 1 kW/m<sup>2</sup>. Godišnji potencijal solarne energije na području Bosne i Hercegovine

procjenjuje se na oko 70,5 miliona GWh. Bosna i Hercegovina ima oko 15% viši potencijal solarne energije u odnosu na srednju Europu, te 30% više i od sjeverne Europe (Holandija, Danska, Velika Britanija). Bosna i Hercegovina ima na raspolaganju ogroman solarni resurs, znatno iznad evropskog prosjeka.

### 3.4 Energetski potencijal vjetra u Bosni i Hercegovini

Evropske analize i podaci govore da je proizvodnja električne energije iz snage vjetra najzastupljenija od obnovljivih izvora energije. Procjenjuje se da će u narednih 8 – 10 godina biti instalirano novih 350 GW. Izgradnja ovih kapaciteta je zahtjevnija od solarnih elektrana. Ipak ostvaruje se začajnja prednost ispred ostalih zbog velikog energetskog potencijala vjetra, tako da prateće tehnologije konstantno napreduju i razvijaju se.

Najveći dio teritorije Bosne i Hercegovine je pogodan za proizvodnju energije iz potencijala vjetra. Mala gustina naseljenosti teritorije i brdoviti reljef daju skoro idealne uslove za gradnju. U Bosni i Hercegovini rade dvije veće vjetroelektrane ukupne snage 86,6 megavata (MW). Ukupna proizvodnja energije u vjetroelektrannama u Bosni i Hercegovini čini 0,8% ukupne potrošnje energije ili oko 2 % ukupne proizvodnje energije.



Slika 5. Neto vrijednost proizvedene električne energije iz obnovljivih izvora za mjesec August 2022. godine, (Izvor: Eurostat.com)



Slika 6. Srednje vrijednosti brzina strujanja zraka na teritoriji BiH, (Izvor: Eurokodovi.ba)

### 3.5 Energetski potencijal vodoničke energije u Bosni i Hercegovini

Do sada se nije radilo na procjenama i mjerenjima koja mogu preciznije odrediti energetski potencijal vodonika u Bosni i Hercegovini. Najznačajnija je činjenica da Bosna i Hercegovina ima ogromne mogućnosti za razvoj u oblasti energije vodonika. Geografija i stanje sa klimom i vodnim potencijalom su neograničeni. Može se reći da Bosna i Hercegovina, u domenu vodoničke energije, ima sve preduslove da postane ono što je bliski istok za naftu. Vodik je najrasprostranjeniji element u svemiru. Računajući atome, vjerovatno više od 90% ukupne mase je vodik. Sunce je napravljen od  $\frac{3}{4}$  vodonika. Ono što na zemlji doživljavamo

kao sunčeve zrake direktan je rezultata spajanja vodonikovih atoma u helij. Vodonik je stvarno „gorivo svemira”. Globalno društvo je izgrađeno na sposobnosti da kontroliše energiju. Sad imamo problem sa zagađenjem i klimatskom promjenama. Definitivno je tehnologije omogućila da se intenzivno zamjene fosilna goriva sa obnovljivim izvorima energije.

### 3.6 Šta činiti – primjeri i prakse

Temeljni izazov s obnovljivom energijom je da slijedi vlastite cikluse i logiku, neovisno o tome kada je želimo koristiti. Dakle, trebamo način da pohranimo višak energije. Za skladištenje velikih količina obnovljive energije, vodonik je najbolja alternativa. Doslovno produžava vjek električne energije od 0 do beskonačno (120 MJ/kg).

Vodonik je satavni dio prirodnog ciklusa vode. Obnovljiva struja pretvorena u vodonik i kisik ponovo postaju energija i čista voda kad se koriste u gorivim ćelijama. Znači da se proizvodnja i infrastruktura može vršiti bez limita i emisije zagađenja uz istu pogodnost koju daju fosilna goriva.

U ovom smislu Bosna i Hercegovina je neograničeno bogata i može vrlo lahko da zamjeni bliski istok. Treba osmisliti i realizirati tehnička rješenja u pogledu nadogradnje, održavanja, razrade, nove primjene i dr. u cilju očuvanja dostignutog nivoa naprednih tehnologija. To podrazumjeva razvoj novih tehnika i koliko je god moguće, samostalan razvoj novih proizvoda proizvedenih novim, vlastitim tehnologijama.

U Bosansko-Hercegovskim uslovima treba poduzeti i pokretati razvojne projekte bliske ili su dio energetskih rješenja.





istovremeno je posebno osjetljiva na rizik zagađenja okoline i štete emisije CO<sup>2</sup>. Praktično je neizbježan rizik emisije CO<sup>2</sup> i drugih štetnih materija. Zbog tih rizika samo drastična ili dramatična promjena može doprinjeti zdravijem okolišu u budućnosti. Bosna i Hercegovina ima vlastitu ozbiljnu proizvodnju energije i može biti neovisna. Međutim oko 70 % proizvedene energije je iz izvora koji stvaraju emisiju CO<sup>2</sup> te je neophodna tranzicija na zelene energije kao što je vodonik.

Bosna i Hercegovine nema određena iskustvo sa vodonikom i u toku je sa određenim segmentima ove oblasti. Ovo je prilika da se u tranziciju ka vodoničkoj ekonomiji ide neopterećeno od početka. Sve tehnološke komponente za izvođenje takvih projekata su fotonaponske ćelije, vjetroagregacije, konstrukcije, elektrolizeri, boce (spremišta) i goriva ćelija. Zato se ovdje nudi jedno viđenje univerzalnog koncepta projektovanja složenog energetskeg sistema, koji će dovesti do proizvodnje vodonika i njegove krajnje eksploatacije.



Slika 8: Zeleni vodonik – osnovni koncept (Izvor: worldbank.blogs, 15.11.2022.) i Koncept eksploatacije resursa, (Izvor: Autor)

Glavna prednost ovog funkcionalnog sistema proizvodnje i raspodjele energije jeste višestepena energetska efikasnost sa zanemarivo malim gubicima i 0 % emisije stakleničkih gasova.

## ZAKLJUČAK

Zaključak je kratak i jasan:

1. Zaokružiti pravni okvir za obnovljive izvore energije u Bosni i Hercegovini.
2. Uspostaviti potrebne organe i urediti mehanizme u Bosni i Hercegovini za korištenje evropskih fondova u oblasti energije, metalne industrije, hrane i poljoprivrede.
3. Uspostaviti edukacione i informacione centre o energetskej tranziciji s ciljem masovnog prihvatanja od strane javnosti energetskeg projekat u domenu obnovljivih izvora energije i pristupu evropskim fondovima i programima razvoja.
4. Odmah pristupiti implementaciji planova i odluka koje se odnose na inteligentne transportne sisteme u Bosni i Hercegovini.

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## 1 INTRODUCTION

This paper is motivated by the fact that the third edition of the "EUROPEAN HYDROGEN WEEK BRUSSELS EXPO" was held in Brussels from October 24 to 28, 2022, and that there are no simple and easy-to-understand stories about alternative energy sources in Bosnia and Herzegovina. These topics are communicated through special channels between "special" participants. Alternative sources and information about them are taboo in Bosnia and Herzegovina. It is also a fact that in this country a much larger number of people have these questions and information than there are actual participants in the communication. An additional problem is that these topics are not discussed in a way that makes them understandable and interesting to the general public.

Therefore, the key challenge in Bosnia and Herzegovina is curiosity, interest, accessibility and comprehensibility of these topics. Unlike Bosnia and Herzegovina, in Europe, the fair in Brussels is pure seven days of information, discussions and meetings on the topic of the hydrogen economy. This is the most important event in Europe where the topic is hydrogen and everything about hydrogen. This event is an explicit indicator of how the uncomplicated cooperation between the European Commission, "Hydrogen Europe" (the umbrella association) and "Hydrogen Europe Research" is realised. Things are very simple, people have a problem of slavery and they came together to solve it. In this partnership, there is no complex of higher or lower values, no balance of power, no interpretation of opinions and similar phenomena. Everything is focused on the question "How to live the future?" and that's it.



Flagship Expo



*Slika 1: Logo-znak asocijacija*

In accordance with Council Regulation (EU) 2021/2085 of December 19, 2021 on the establishment of joint ventures within the Horizon Europe program and on the repeal of Regulation (EC) no. 219/2007 ... , and (EU) no. 642/2014, an international non-profit association named "Hydrogen Europe" was established. The association was founded with a focus on European industrial grouping for a joint technology initiative for hydrogen and fuel cells and has a vision to ensure a society with zero CO<sub>2</sub> emissions with the help of pure hydrogen technology.

## 2 MOBILITY IN BOSNIA AND HERZEGOVINA AS A SOCIAL CHALLENGE

The European Union has adopted common rules for protection, social standards, technical and safety standards, state aid and market liberalization of road transport, rail and inland waterway transport, combined transport, and air and maritime transport.

Bosnia and Herzegovina must be part of European trends and must approach smart solutions advocated by European politics and professions. The traffic and transport system should be resource-efficient, acceptable for the climate and the environment, safe and reliable for the benefit of citizens, the economy and society. Bosnia and Herzegovina, as part of Europe, must meet the growing needs for the mobility of its citizens and goods caused by new demographic and social changes with the conditions of economic success and the requirements of an energy-efficient.

### **2.1 Intelligent, green and integrated traffic**

Bosnia and Herzegovina records a mild level of preparedness and progress in traffic and transport when it comes to the Framework Transport Strategy and Action Plans. It is necessary to continue harmonization with the *acquis* and its effective implementation in all areas of transport and at all levels of government. Bosnia and Herzegovina needs to strengthen administrative capacities in terms of road safety, and in terms of executive, inspection and investigative bodies for the country's traffic and transport system. Bosnia and Herzegovina should:

- [1] develop capacities to reduce traffic accidents with fatal outcome and establish a system for permanent and continuous collection of data on traffic accidents;
- [2] achieve independence and establish capacities for regulatory bodies in the field of transport;
- [3] creates a strategic plan and regulations, and provides capacities and resources for the implementation of an intelligent transport system (ITS).

The basic features of the state of the traffic and transportation system in Bosnia and Herzegovina are as follows:

- The development of the transport sector and the speed of structural

adjustment and reforms are insufficient.

- Investments have been delayed due to political blockages and lack of cooperation between levels of government.
- Borrowing capacities are limited.
- Financial resources for the preparation of technical documentation are limited.
- The focus on the implementation of short-term and medium-term measures has been lost.
- Not fully aligned with the Intelligent Transport Systems (ITS) Directive.
- Failure to encourage multimodality and ensure the implementation of relevant traffic laws.
- Bosnia and Herzegovina continues to actively participate in the EU macro-regional strategies for the development of the Danube region (EUSDR) and the Adriatic-Ionian region (EUSAIR).
- The country is moderately prepared for road traffic.
- Measures should be implemented to develop the TEN-T road network resistant to climate.
- The law on international road transport of dangerous goods has not been adopted.
- Amendments to the Law on Railways, which are a prerequisite for the formation of independent bodies for railway safety, have not been adopted.

Sustainable mobility is ensured by radical changes in the traffic and transport system, application of discoveries in traffic research and consistent implementation of greener, safer, more reliable and smarter transport solutions in Bosnia and Herzegovina. Traffic and transport is the main driver of economic competitiveness and growth. Traffic and transport industry make up about 8% of GDP in Bosnia and Herzegovina. In Bosnia and Herzegovina, over 98% of traffic depends on fossil fuels. Citizens and companies expect a traffic and transport system that is accessible to

everyone, safe and protected. A crucial role in the achievement of the goals will be played by research and innovation aligned with political goals and the intention to achieve the limitation of global warming to 2 °C, reduced CO2 emissions by 60%, congestion, costs of accidents and road deaths.

## 2.2 Objectives of the key policies of the European Union

As far as European policies are concerned, there are four key ones designed with the intention of enabling the necessary level of organization of a specific way of access to any type of transport.

The most important thing is to keep the focus on achieving the goals:

- Ecologically acceptable and efficient transportation (climate, environment, quality, efficiency and resources).
- Optimization and rationalization of mobility (less crowds, safety, alignment, new direction).
- Ensure the leading role of the European transport industry (strengthening competitiveness, services...).
- Establishing policies (socio-economic and behavioral research).

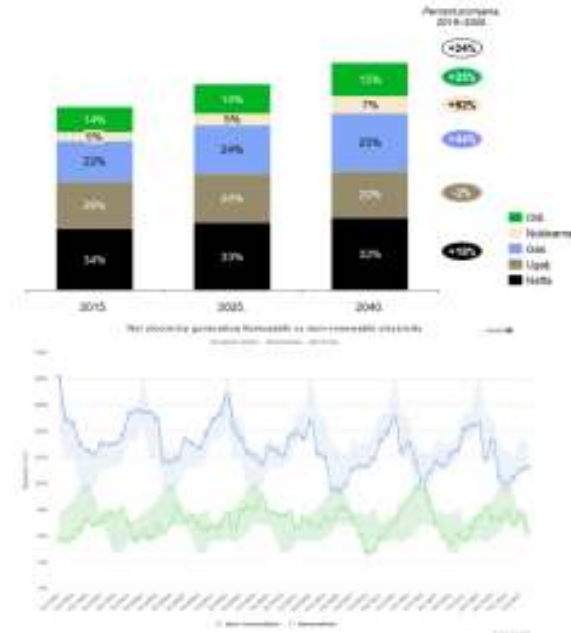
## 3 ENERGY POTENTIAL – ALTERNATIVES

The energy sector at the global and local level is marked by drastic changes and transitions. Global policies are based on, or forced upon, a shift towards clean energy and the accelerated development of new and commercially available technologies. That is why the trends of developed and developing countries differ.

### 3.1 Global energy trends

Based on analytical monitoring of changes, it is estimated that the demand for energy

will grow by 24% in the next 20 years (as of 2015). It is expected that the war will come from China, India and developing countries. Demand is driven by strong industrialization and rapidly growing economies. The share of oil and coal will fall from 60% in 2015 to 52% by 2040. Regardless of the decreasing trend in the share of oil, by 2040 the demand for primary energy from oil will increase by 18% in absolute terms. In addition to developing economies, the increase will refer to the transport sector and the petrochemical industry. Estimates are that electric and hybrid vehicles will make up 15% to 20% of the total vehicle fleet, which will reduce oil consumption..



**Figure 2.** Structure of global demand for primary energy, 2015-2040 (Source: Framework Energy Strategy of BiH until 2035) and Net electricity produced from renewable and non-renewable sources, (Source: Eurostat)

### 3.2 Consumption and production of energy in Bosnia and Herzegovina

The following tables provide the main data on the energy indicators of production and consumption in Bosnia and Herzegovina for the year 2019.

Produced	Quantity (GWh)	Percentage (%)
Gross production of electricity	17.493	100
in hydroelectric power plants	6.172	35,3
in thermal power plants	10.625	60,7
in industrial power plants and others (wind and solar power plants)	696	4

**Table 1.** Electricity production in Bosnia and Herzegovina (Source: Author based on statistical reports)

Consumption	Quantity (GWh)	Percentage (%)
households	7.497	43
industry	5.737	32,9
other consumers (construction, transport and agriculture)	4.202	24,1

**Table 2:** Electricity consumption in Bosnia and Herzegovina (Source: Author based on statistical reports)

Produced	Quantity (GWh)	Percentage (%)
Total heat energy production	5.571	100%
in heating plants	3.301	59,2
in thermal power plants	1.688	30,3
in industrial power plants	582	10,5

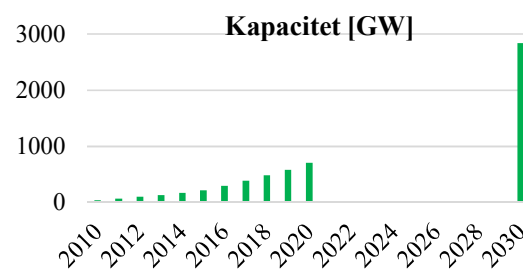
**Table 3:** Heat energy production in Bosnia and Herzegovina (Source: Author based on statistical reports)

Consumption	Quantity (TJ)	Percentage (%)
households	4.240	76,1
industry and other consumers	1.331	23,9

**Table 4:** Thermal energy consumption in Bosnia and Herzegovina (Source: Author based on statistical reports)

### 3.3. Energy potential of solar energy in Bosnia and Herzegovina

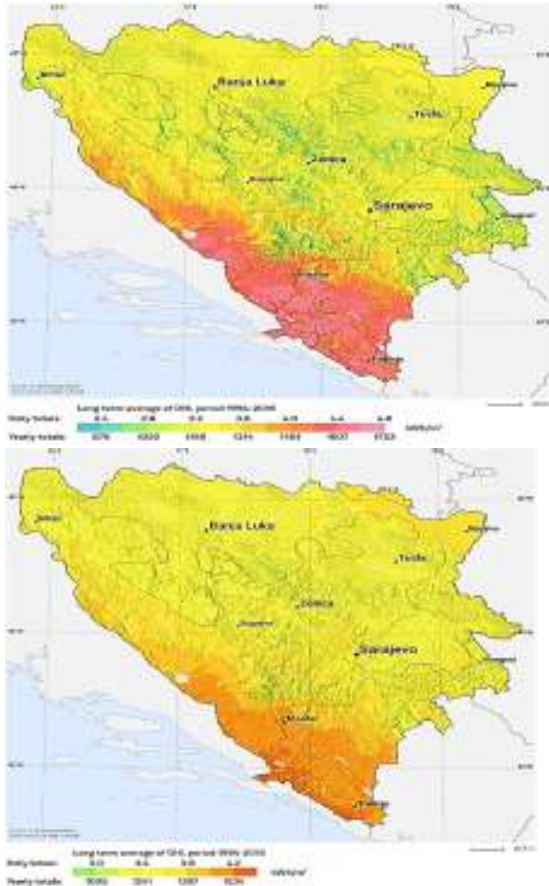
The development of advanced technologies on a global level has led to drastic changes that have changed the way of living, communicating, relaxing, working, doing business, and living. Over the past few years, over 100 GW of solar infrastructure and photovoltaic panels have been installed in one year. In this way, the total power of these power plants reached a power of over 500 GW. Newly built solar energy capacities exceed the power capacity of all other newly built electric power capacities.



**Figure 3.** Capacities of photovoltaic power plants in the world and expected values in 2030 (Source: Author) and map of the photovoltaic potential of the territory of Bosnia and Herzegovina (Source: <https://solargis.com/>)

It is known that the sun radiates enormous energy, of which about 10,000 TW ends up on the earth's surface. The possibility of using this energy is much higher compared

to other renewable sources. Bosnia and Herzegovina has the potential to develop extraordinary advantages in this industry compared to all other European countries, primarily due to its geographical position and the nature present in it.



**Figure 4.** Average value of irradiation for optimally and horizontally placed panels in Bosnia and Herzegovina, (Source: <https://solarGIS.com/>)

No	Area	Amount of solar energy (average)
1.	Planet Earth	1500 kWh/m <sup>2</sup>
2.	south of the USA, Australia and most of Africa	2200 kWh/m <sup>2</sup>
3.	Northern Europe and Canada	1100 kWh/m <sup>2</sup>
4.	Bosnia and Herzegovina	1240 do 1600 kWh/m <sup>2</sup>

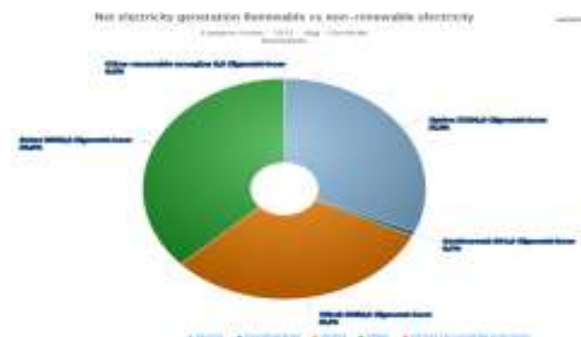
5.	countries of Central and Northern Europe	1000 do 1150 kWh/m <sup>2</sup>
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**Table 5:** Average amount of solar energy reaching the Earth's surface annually (Source: Author)

The thermal power of solar radiation on the earth's surface on a clear day is approx. 1 kW/m<sup>2</sup>. The annual potential of solar energy in Bosnia and Herzegovina is estimated at around 70.5 million GWh. Bosnia and Herzegovina has about 15% higher solar energy potential compared to Central Europe, and 30% more than Northern Europe (Netherlands, Denmark, Great Britain). Bosnia and Herzegovina has a huge solar resource at its disposal, well above the European average.

### 3.4. Energy potential of wind in Bosnia and Herzegovina

European analyzes and data show that the production of electricity from wind power is the most common of renewable energy sources. It is estimated that a new 350 GW will be installed in the next 8-10 years. Building these capacities is more demanding than solar power plants. However, a significant advantage over the others is realized due to the great energy potential of the wind, so that the accompanying technologies are constantly advancing and developing.



**Figure 5.** Net value of electricity produced from renewable sources for the month of August 2022, (Source: Eurostat.com)



**Figure 6.** Mean values of air flow speeds on the territory of Bosnia and Herzegovina, (Source: Eurokodovi.ba)

The largest part of the territory of Bosnia and Herzegovina is suitable for the production of energy from wind potential. The territory's low population density and hilly relief provide almost ideal conditions for construction. In Bosnia and Herzegovina, two larger wind farms with a total capacity of 86.6 megawatts (MW) are operating. Total energy production in wind farms in Bosnia and Herzegovina accounts for 0.8% of total energy consumption or about 2% of total energy production.

### 3.5. Energy potential of hydrogen energy in Bosnia and Herzegovina

Until now, no work has been done on assessments and measurements that can more precisely determine the energy potential of hydrogen in Bosnia and Herzegovina. The most significant fact is that Bosnia and Herzegovina has enormous opportunities for development in the field of hydrogen energy. Geography and condition with climate and water potential are unlimited. It can be said that Bosnia and Herzegovina, in the field of hydrogen energy, has all the prerequisites to become what the Middle East is for oil. Hydrogen is the most abundant element in the universe. Counting atoms, probably more than 90% of the total mass is hydrogen. The sun is made of  $\frac{3}{4}$  hydrogen. What we perceive on earth as the sun's rays is the direct result of the fusion of hydrogen atoms into helium.

Hydrogen is the real "space fuel". Global society is built on the ability to control energy. Now we have a problem with pollution and climate change. Technology has definitely made it possible to intensively replace fossil fuels with renewable energy sources.

### 3.6. What to do - examples and practices

The fundamental challenge with renewable energy is that it follows its own cycles and logic, regardless of when we want to use it. So we need a way to store the excess energy. For storing large amounts of renewable energy, hydrogen is the best alternative. It literally extends the life of electricity from 0 to infinity (120 MJ/kg). Hydrogen is an integral part of the natural water cycle. Renewable electricity converted into hydrogen and oxygen becomes energy and clean water again when used in fuel cells. It means that production and infrastructure can be carried out without limits and pollution emissions with the same convenience that fossil fuels provide.

In this sense, Bosnia and Herzegovina is infinitely rich and can easily replace the Middle East. It is necessary to design and implement technical solutions in terms of upgrading, maintenance, development, new applications, etc. in order to preserve the achieved level of advanced technologies. This implies the development of new techniques and, as far as possible, the independent development of new products produced with new, own technologies. In the conditions of Bosnia and Herzegovina, development projects related to or part of energy solutions should be undertaken and launched. There are several current projects that can foreshadow a better future, such as:

- development of a multifunctional electric vehicle, development and production of an electric karting vehicle, and development and production of a universal vehicle



concept intended for off-road conditions.

- A single PEM fuel cell was designed and built, with an active catalyst area of 23x23 mm. The fuel cell was tested in the laboratory and the results obtained are that the voltage is 0.9 V and the current is 50 mA.
- Research and development of more automated and robotic dynamic systems. Multipurpose drones with several variants of drives and shapes are current.

The ultimate goal of the projects is the practical use of developed and produced devices such as a car with a fuel cell system produced in-house. These are good examples and good practices.



*Figure 7. Development projects of JU "CNT"  
Sarajevo (Source: Author)*

#### **4 UNIVERSAL CONCEPT OF INFRASTRUCTURE DESIGN FOR GREEN HYDROGEN PRODUCTION**

Every production has the risk of polluting the environment and creating harmful emissions into the air. Energy production is always a big project and requires an investment of time, work, money, and other resources, and at the same time it is particularly sensitive to the risk of environmental pollution and damage from CO emissions. The risk of emission of CO<sub>2</sub> and other harmful substances is practically unavoidable. Because of these risks, only a drastic or dramatic change can contribute to a healthier environment in the future. Bosnia and Herzegovina has its own serious energy production and can be independent. However, about 70% of the produced energy comes from sources that generate CO<sub>2</sub> emissions, so a transition to green energies such as hydrogen is necessary. Bosnia and Herzegovina does not have specific experience with hydrogen and is up to date with certain segments of this field. This is an opportunity to go into the transition to the hydrogen economy unencumbered from the beginning. All technological components for carrying out such projects are photovoltaic cells, wind turbines, structures, electrolyzers, bottles (storage) and fuel cells. That's why here we offer one view of the universal concept of designing a complex energy system, which will lead to the production of hydrogen and its final exploitation.



**Figure 9:** Green hydrogen - basic concept  
(Source: worldbank.blogs, 15.11.2022) and  
Resource exploitation concept, (Source:  
Author)

The main advantage of this functional system of energy production and distribution is multi-level energy efficiency with negligible losses and 0% greenhouse gas emissions.

## CONCLUSION

The conclusion is short and clear:

- 1) Complete the legal framework for renewable energy sources in Bosnia and Herzegovina.
- 2) Establish the necessary authorities and organize mechanisms in Bosnia and Herzegovina for the use of European funds in the field of energy, metal industry, food and agriculture.
- 3) Establish educational and information centers on energy transition with the aim of mass acceptance by the public of energy projects in the domain of renewable energy sources and access to European funds and development programs.

- 4) Immediately begin the implementation of plans and decisions related to intelligent transport systems in Bosnia and Herzegovina.

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